

# **MULTIPLE LINES OF EVIDENCE INTEGRATION**

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**Southern California Coastal Water Research Project**

# PREVIOUS MEETING

- **Presented a framework with equal weighting among Lines of Evidence (LOEs)**
  - 4x4x4 tables
  - You asked us to add narrative descriptions of each box
  
- **You asked us to consider an alternate framework**
  - Separate magnitude of effect from likelihood that effect was chemically mediated
  - Two-step process

# GOALS FOR THIS PRESENTATION

- **Present an alternative framework**
- **Evaluate both frameworks in a validation context**
- **Recommend a preferred framework**

# ALTERNATE FRAMEWORK

- **Severity of effect**
  - Unaffected
  - Low effect
  - Moderate effect
  - Large effect
  
- **Potential that effects are chemically mediated**
  - Minimal potential
  - Low potential
  - Moderate potential
  - High potential

# SEVERITY OF EFFECT

## Toxicity

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	<b>Nontoxic</b>	<b>Low Toxicity</b>	<b>Moderate Toxicity</b>	<b>High Toxicity</b>
<b>Reference</b>	<b>Unaffected</b>	<b>Unaffected</b>	<b>Unaffected</b>	<b>Low Effect</b>
<b>Low Disturbance</b>	<b>Unaffected</b>	<b>Low Effect</b>	<b>Low Effect</b>	<b>Low Effect</b>
<b>Moderate Disturbance</b>	<b>Low Effect</b>	<b>Moderate Effect</b>	<b>Moderate Effect</b>	<b>Moderate Effect</b>
<b>High Disturbance</b>	<b>Moderate Effect</b>	<b>High Effect</b>	<b>High Effect</b>	<b>High Effect</b>

# POTENTIAL THAT EFFECTS ARE CHEMICALLY MEDIATED

## Toxicity

	Nontoxic	Low Toxicity	Moderate Toxicity	High Toxicity
Minimal Exposure	Minimal Potential	Minimal Potential	Low Potential	Low Potential
Low Exposure	Minimal Potential	Low Potential	Low Potential	Moderate Potential
Moderate Exposure	Low Potential	Moderate Potential	Moderate Potential	Moderate Potential
High Exposure	Moderate Potential	Moderate Potential	High Potential	High Potential

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# STATION ASSESSMENT

## Severity of Effect

	Unaffected	Low Effect	Moderate Effect	High Effect
Minimal Potential	Unimpacted	Likely Unimpacted	Likely Unimpacted	Likely Unimpacted
Low Potential	Unimpacted	Likely Unimpacted	Possibly Impacted	Possibly Impacted
Moderate Potential	Likely Unimpacted	Possibly Impacted	Likely Impacted	Clearly Impacted
High Potential	Likely Unimpacted	Likely Impacted	Clearly Impacted	Clearly Impacted

Potential that Effects are Chemically Mediated

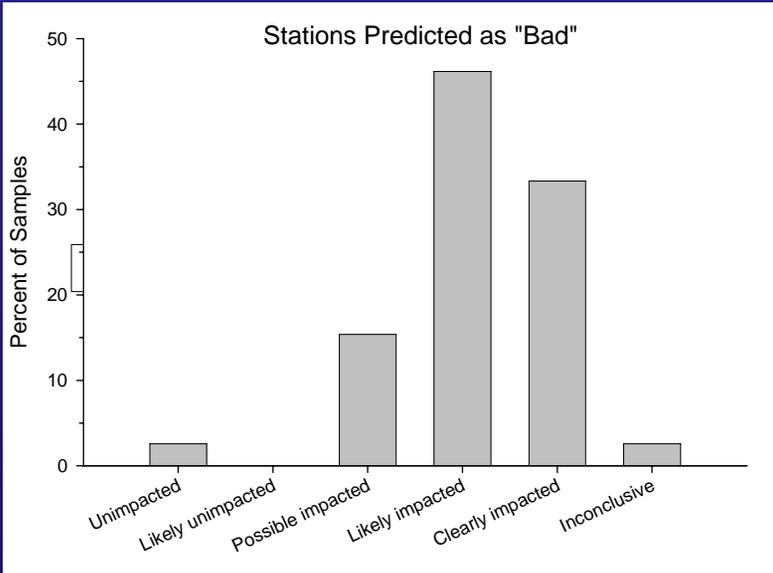
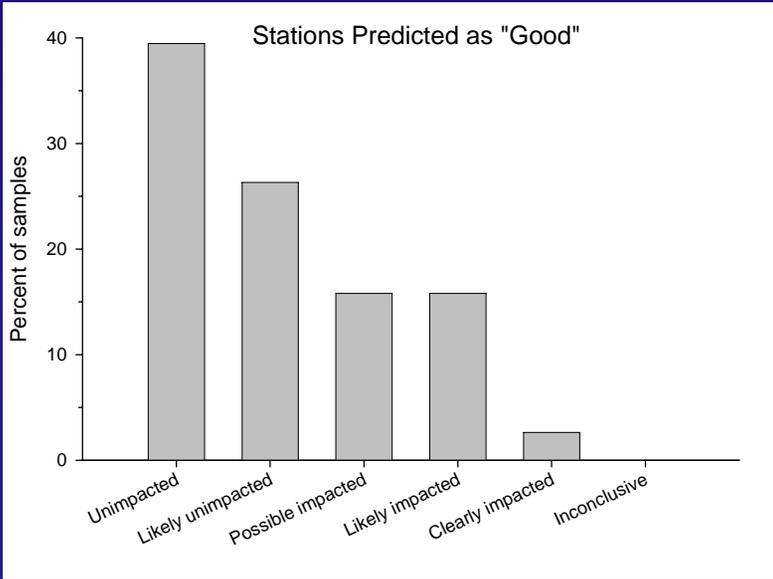
# TWO EVALUATION APPROACHES

- **Good/Bad Waterbodies**
  - Can sites be distinguished from waterbodies with “known” condition?
- **Expert Opinion**
  - Similar to approach used for benthos

# GOOD/BAD WATERBODIES

- **Bad waterbodies**
  - Used areas identified by California’s Bay Protection and Toxic Cleanup Program (BPTCP)
  - BPTCP conducted a substantial sampling program to identify worst sites in the state
  - They went through a vetting process
- **Good waterbodies**
  - Collated all data for available chemistry and/or toxicity
  - Identified locales where these were consistently good
- **Resulted in 77 sites with “known” condition**
  - 38 good sites
  - 39 bad sites

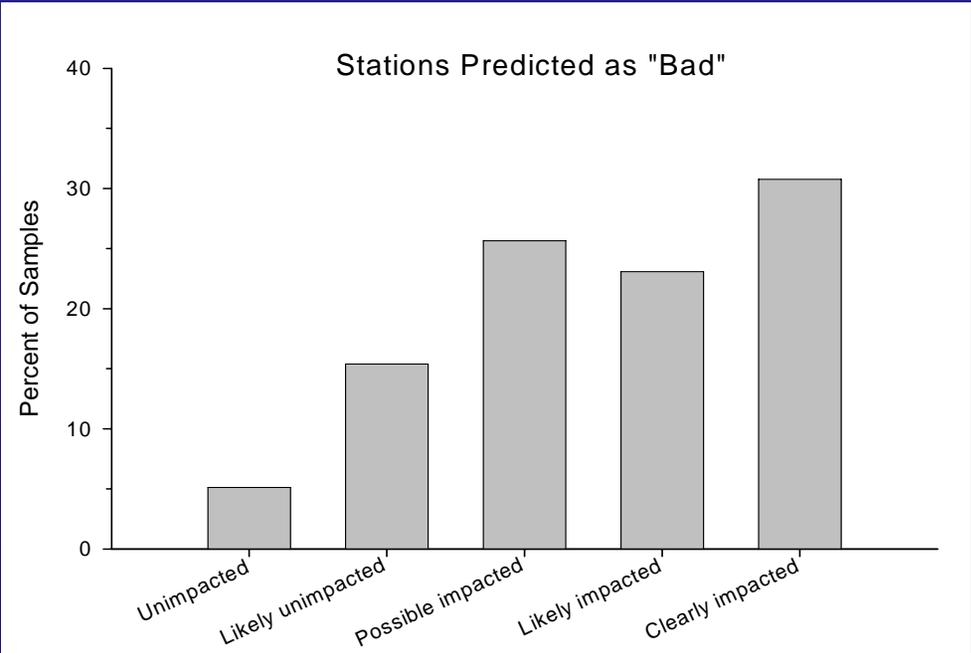
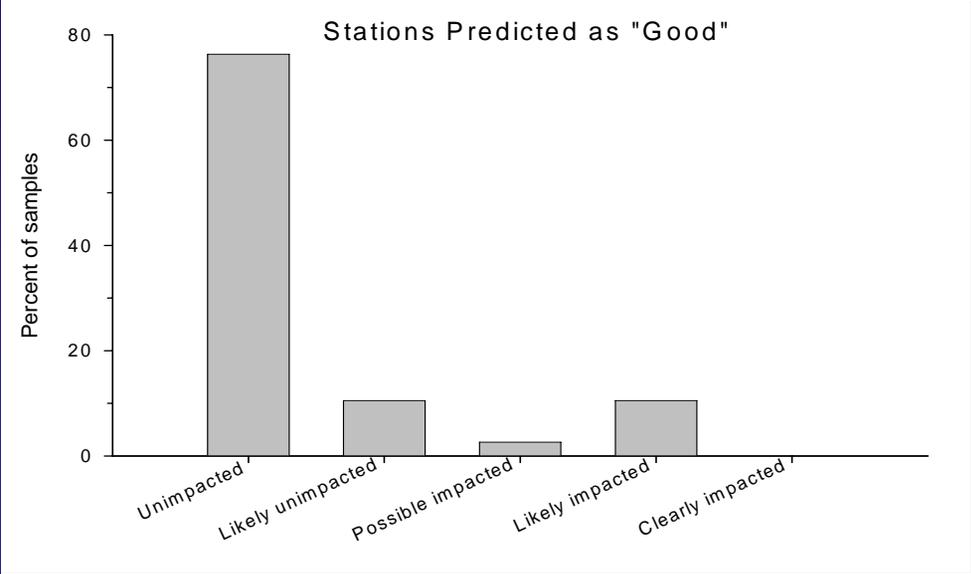
# ORIGINAL FRAMEWORK



# ORIGINAL FRAMEWORK

Station	"Known" Condition	COMPONENT CATEGORY			ASSESSMENT CATEGORY
		Chemistry	Benthos	Toxicity	
BB70	Good	Moderate	Moderate	Low	Likely Impacted
CA00-0001	Good	Moderate	Moderate	High	Clearly Impacted
CA00-0003	Good	Low	Reference	Moderate	Possibly Impacted
CA00-0010	Good	Low	Moderate	High	Likely Impacted
CA00-0012	Good	Low	Moderate	High	Likely Impacted
CA00-0032	Good	Moderate	Low	Moderate	Likely Impacted
CA00-0034	Good	Moderate	Reference	Low	Possibly Impacted
CA00-0036	Good	Moderate	Reference	Moderate	Likely Impacted
28	Good	Low	Reference	Moderate	Possibly Impacted
30	Good	Low	Reference	Moderate	Possibly Impacted
4400	Good	Moderate	Reference	Moderate	Likely Impacted
2159	Good	Low	Reference	Moderate	Possibly Impacted
2240	Good	Low	Low	Low	Possibly Impacted
5787	Bad	Low	Reference	Reference	Unimpacted

# ALTERNATE FRAMEWORK



# ALTERNATE FRAMEWORK

Station	"Known" Condition	COMPONENT CATEGORY			ASSESSMENT CATEGORY		
		Chemistry	Benthos	Toxicity	Potential for Chemically-mediated Effect	Severity of Effect	Alternate Assessment Category
BB70	Good	Moderate	Moderate	Low	Moderate	Moderate	Likely Impacted
CA00-0001	Good	Moderate	Moderate	High	Moderate	Moderate	Likely Impacted
CA00-0010	Good	Low	Moderate	High	Moderate	Moderate	Likely Impacted
CA00-0012	Good	Low	Moderate	High	Moderate	Moderate	Likely Impacted
CA00-0032	Good	Moderate	Low	Moderate	Moderate	Low	Possibly Impacted
4852	Bad	Low	Moderate	Nontoxic	Minimal	Low	Likely Unimpacted
4856	Bad	Low	Moderate	Nontoxic	Minimal	Low	Likely Unimpacted
5108	Bad	Moderate	Moderate	Nontoxic	Low	Low	Likely Unimpacted
5787	Bad	Low	Reference	Nontoxic	Minimal	Unaffected	Unimpacted
C11	Bad	High	Reference	Nontoxic	Moderate	Unaffected	Likely Unimpacted
C12	Bad	High	Low	Nontoxic	Moderate	Unaffected	Likely Unimpacted
P11	Bad	High	Low	Nontoxic	Moderate	Unaffected	Likely Unimpacted
P12	Bad	Moderate	Low	Nontoxic	Low	Unaffected	Unimpacted

# EXPERT OPINION APPROACH

- **Six experts**
- **25 sites**
  - Subset of sites used for the benthic evaluation
- **Sent them data for each site**
  - Chemistry
  - Toxicity (single amphipod test)
  - Benthic assessment category
- **Asked them to define condition**
  - Ranked from highest to lowest
  - Five assessment categories plus “inconclusive”

# EXPERTS

- **Peter Chapman**
- **Ed Long**
- **Don MacDonald**
- **Rusty Fairey**
- **Walter Berry**
- **Tom Gries**

# EXPERT OPINION APPROACH

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- **25 sites**
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- **Sent them data for each site**
  - Chemistry
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  - Benthic assessment category
- **Asked them to define condition**
  - Ranked from highest to lowest
  - Five assessment categories plus “inconclusive”

# CORRELATION FOR STATION RANKING

		Expert			
		2	3	5	6
E x p e r t	1	<b>.93</b>	<b>.97</b>	<b>.96</b>	<b>.94</b>
	2		<b>.95</b>	<b>.94</b>	<b>.89</b>
	3			<b>.93</b>	<b>.92</b>
	5				<b>.91</b>

Station #	Reviewer 1	Reviewer 2	Reviewer 3	Reviewer 4	Reviewer 5	Reviewer 6
1	1	1	2	1	1	1
2	2	3	3	3	2	2
3	2	2	3	3	2	2
4	1	2	2	2	1	1
5	4	3	4	3	2	4
6	1	1	2	1	1	1
7	2	x	3	x	2	x
8	4	x	4	x	3	x
9	3	x	4	3	2	x
10	4	3	4	5	3	4
11	5	3	4	5	4	5
12	3	2	3	3	2	2
13	3	3	3	3	2	3
14	4	3	4	3	4	4
15	5	3	4	3	4	4
16	3	2	3	x	1	3
17	3	2	3	4	1	3
18	1	1	2	1	1	1
19	5	3	5	5	5	5
20	5	4	5	5	5	5
21	5	4	5	5	5	5
22	5	4	5	5	5	5
23	1	1	2	x	1	1
24	1	1	2	x	1	1
25	1	1	2	x	1	1

Unimpacted
Likely unimpacted
Possibly impacted
Likely impacted
Clearly impacted
x Inconclusive

Station #	Reviewer 1	Reviewer 2	Reviewer 3	Reviewer 4	Reviewer 5	Reviewer 6	Original Framework	Alternate Framework
1	1	1	2	1	1	1	1	1
2	2	3	3	3	2	2	3	2
3	2	2	3	3	2	2	3	3
4	1	2	2	2	1	1	1	1
5	4	3	4	3	2	4	4	4
6	1	1	2	1	1	1	1	1
7	2	x	3	x	2	x	2	2
8	4	x	4	x	3	x	4	4
9	3	x	4	3	2	x	4	2
10	4	3	4	5	3	4	5	4
11	5	3	4	5	4	5	5	5
12	3	2	3	3	2	2	4	2
13	3	3	3	3	2	3	4	3
14	4	3	4	3	4	4	5	5
15	5	3	4	3	4	4	4	4
16	3	2	3	x	1	3	2	1
17	3	2	3	4	1	3	4	3
18	1	1	2	1	1	1	1	1
19	5	3	5	5	5	5	5	5
20	5	4	5	5	5	5	5	5
21	5	4	5	5	5	5	5	5
22	5	4	5	5	5	5	5	5
23	1	1	2	x	1	1	1	1
24	1	1	2	x	1	1	1	1
25	1	1	2	x	1	1	1	1

Unimpacted  
Likely unimpacted  
Possibly impacted  
Likely impacted  
Clearly impacted  
x Inconclusive

# COMPARISON TO MEDIAN EXPERT

	Reviewer 1	Reviewer 2	Reviewer 3	Reviewer 4	Reviewer 5	Reviewer 6	Original Framework	Alternate Framework
<b>Error rate</b>	6/25	16/22	14/25	10/19	14/25	5/22	12/25	9/25
<b>Percent</b>	24%	73%	56%	53%	56%	23%	48%	36%
<b>Bias</b>	+4	-14	+13	+7	-14	-1	+10	-1
<b>Impacted/ unimpacted</b>	8%	18%	16%	16%	28%	9%	16%	12%

ID	Benthos	Toxicity	Chemistry		Expert Category	Original Framework	Alternative Framework		Alternative Framework Exposure Potential	Alternative Framework Severity of Effects
1	Reference	Nontoxic	Minimal		Unimpacted	Unimpacted	Unimpacted		Minimal	Unaffected
2	Low	Moderate	Low		Likely Unimpacted	Possibly Impacted	Likely Unimpacted		Minimal	Minimal
3	Reference	High	Low		Likely Unimpacted	Possibly Impacted	Possibly Impacted		Moderate	Minimal
4	Reference	Low	Minimal		Likely Unimpacted	Unimpacted	Unimpacted		Minimal	Unaffected
5	Low	High	High		Possibly Impacted	Likely Impacted	Likely Impacted		High	Minimal
6	Reference	Nontoxic	Minimal		Unimpacted	Unimpacted	Unimpacted		Minimal	Unaffected
7	Moderate	Nontoxic	Minimal		Likely Unimpacted	Likely Unimpacted	Likely Unimpacted		Minimal	Minimal
8	High	Nontoxic	High		Likely Impacted	Likely Impacted	Likely Impacted		Moderate	Moderate
9	Moderate	Nontoxic	Moderate		Possibly Impacted	Likely Impacted	Likely Unimpacted		Minimal	Minimal
10	Moderate	High	Moderate		Likely Impacted	Clearly Impacted	Likely Impacted		Moderate	Moderate
11	Moderate	High	High		Likely Impacted	Clearly Impacted	Clearly Impacted		High	Moderate
12	Reference	Moderate	High		Likely Unimpacted	Likely Impacted	Likely Unimpacted		High	Unaffected
13	Low	Low	High		Possibly Impacted	Likely Impacted	Possibly Impacted		Moderate	Minimal
14	Moderate	Moderate	High		Likely Impacted	Clearly Impacted	Clearly Impacted		High	Moderate
15	Low	High	High		Likely Impacted	Likely Impacted	Likely Impacted		High	Minimal
16	Low	Nontoxic	Low		Possibly Impacted	Likely Unimpacted	Unimpacted		Minimal	Unaffected
17	Low	Low	High		Possibly Impacted	Likely Impacted	Possibly Impacted		Moderate	Minimal
18	Reference	Nontoxic	Minimal		Unimpacted	Unimpacted	Unimpacted		Minimal	Unaffected
19	Moderate	Moderate	High		Clearly Impacted	Clearly Impacted	Clearly Impacted		High	Moderate
20	High	High	High		Clearly Impacted	Clearly Impacted	Clearly Impacted		High	High
21	High	High	High		Clearly Impacted	Clearly Impacted	Clearly Impacted		High	High
22	High	High	High		Clearly Impacted	Clearly Impacted	Clearly Impacted		High	High
23	Reference	Nontoxic	Minimal		Unimpacted	Unimpacted	Unimpacted		Minimal	Unaffected
24	Reference	Nontoxic	Minimal		Unimpacted	Unimpacted	Unimpacted		Minimal	Unaffected
25	Reference	Nontoxic	Minimal		Unimpacted	Unimpacted	Unimpacted		Minimal	Unaffected

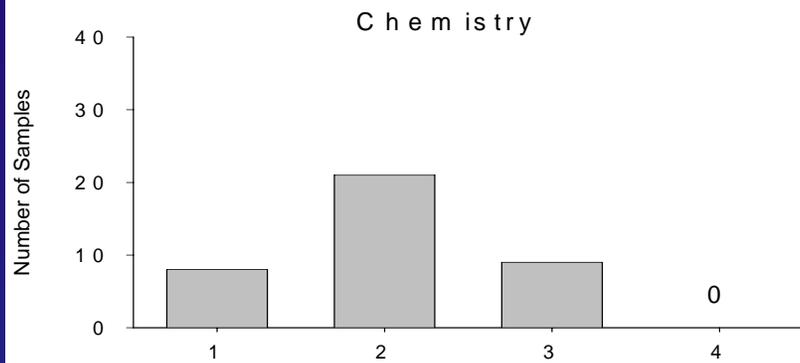
# ADVANTAGES OF ALTERNATE FRAMEWORK

- **Lower error rate**
  - Least bias of any method/reviewer
- **Easier to communicate**
  - Like the separation of effects and potential for chemical mediation
- **More opportunities for sequential implementation**
  - Potentially more cost-effective

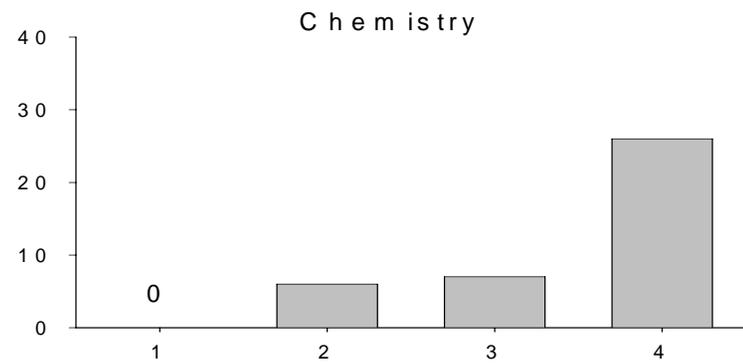
# NEXT STEPS

- **Respond to your feedback**
- **Get input from the stakeholders advisory committee**
  - Want to know their preferences between framework approaches
  - They had a lot of interest in the validation process
- **Address missing data scenarios**

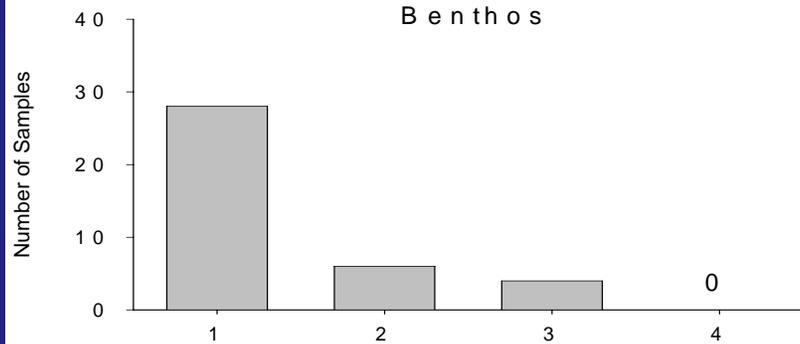
Samples Predicted As "Good"



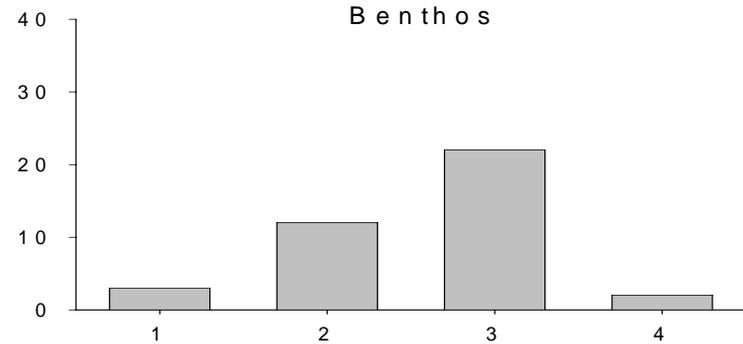
Samples Predicted As "Bad"



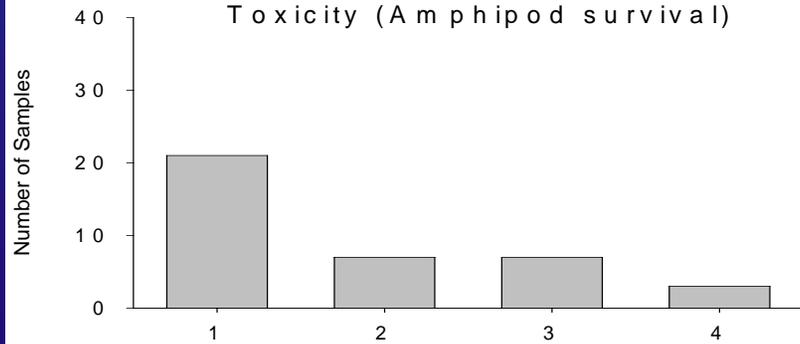
Benthos



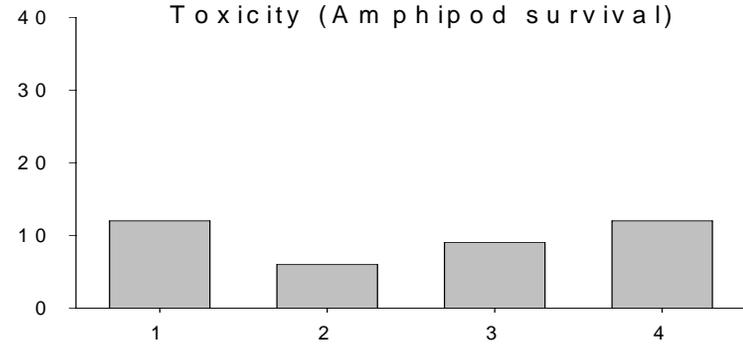
Benthos



Toxicity (Amphipod survival)



Toxicity (Amphipod survival)



Assigned Threshold Category

Assigned Threshold Category

# CHEMISTRY: Minimal Exposure

## Toxicity

	<b>Nontoxic</b>	<b>Low Toxicity</b>	<b>Moderate Toxicity</b>	<b>High Toxicity</b>
<b>Reference</b>	<b>Unimpacted</b>	<b>Unimpacted</b>	<b>Likely Unimpacted</b>	<b>Inconclusive</b>
<b>Low Disturbance</b>	<b>Unimpacted</b>	<b>Likely Unimpacted</b>	<b>Possibly Impacted</b>	<b>Possibly Impacted</b>
<b>Moderate Disturbance</b>	<b>Likely Unimpacted</b>	<b>Possibly Impacted</b>	<b>Possibly Impacted</b>	<b>Likely Impacted</b>
<b>High Disturbance</b>	<b>Inconclusive</b>	<b>Possibly Impacted</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>

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# CHEMISTRY: Low Exposure

## Toxicity

	<b>Nontoxic</b>	<b>Low Toxicity</b>	<b>Moderate Toxicity</b>	<b>High Toxicity</b>
<b>Reference</b>	<b>Unimpacted</b>	<b>Likely Unimpacted</b>	<b>Possibly Impacted</b>	<b>Possibly Impacted</b>
<b>Low Disturbance</b>	<b>Likely Unimpacted</b>	<b>Possibly Impacted</b>	<b>Possibly Impacted</b>	<b>Likely Impacted</b>
<b>Moderate Disturbance</b>	<b>Possibly Impacted</b>	<b>Possibly Impacted</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>
<b>High Disturbance</b>	<b>Possibly Impacted</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>

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# CHEMISTRY: Moderate Exposure

## Toxicity

	<b>Nontoxic</b>	<b>Low Toxicity</b>	<b>Moderate Toxicity</b>	<b>High Toxicity</b>
<b>Reference</b>	<b>Likely Unimpacted</b>	<b>Possibly Impacted</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>
<b>Low Disturbance</b>	<b>Possibly Impacted</b>	<b>Possibly Impacted</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>
<b>Moderate Disturbance</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>	<b>Clearly Impacted</b>	<b>Clearly Impacted</b>
<b>High Disturbance</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>	<b>Clearly Impacted</b>	<b>Clearly Impacted</b>

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# CHEMISTRY: High Exposure

## Toxicity

	<b>Nontoxic</b>	<b>Low Toxicity</b>	<b>Moderate Toxicity</b>	<b>High Toxicity</b>
<b>Reference</b>	<b>Inconclusive</b>	<b>Possibly Impacted</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>
<b>Low Disturbance</b>	<b>Possibly Impacted</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>
<b>Moderate Disturbance</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>	<b>Clearly Impacted</b>	<b>Clearly Impacted</b>
<b>High Disturbance</b>	<b>Likely Impacted</b>	<b>Likely Impacted</b>	<b>Clearly Impacted</b>	<b>Clearly Impacted</b>

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# TERMINOLOGY

<b>CHEMISTRY (Exposure)</b>	<b>TOXICITY (Toxic)</b>	<b>BENTHOS (Disturbance)</b>	<b>POTENTIAL FOR CHEMICALLY - MEDIATED EFFECTS (Potential)</b>	<b>SEVERITY OF EFFECT (Effect)</b>	<b>STATION ASSESSMENT (Impact)</b>
<b>Minimal Exposure</b>	<b>Nontoxic</b>	<b>Reference</b>	<b>Minimal Potential</b>	<b>Unaffected</b>	<b>Unimpacted</b>
<b>Low Exposure</b>	<b>Low Toxicity</b>	<b>Low Disturbance</b>	<b>Low Potential</b>	<b>Low Effect</b>	<b>Likely Unimpacted</b>
<b>Moderate Exposure</b>	<b>Moderate Toxicity</b>	<b>Moderate Disturbance</b>	<b>Moderate Potential</b>	<b>Moderate Effect</b>	<b>Possibly Impacted</b>
<b>High Exposure</b>	<b>High Toxicity</b>	<b>High Disturbance</b>	<b>High Potential</b>	<b>High Effect</b>	<b>Likely Impacted</b>
					<b>Clearly Impacted</b>